# THE NUMBER GAME

STUDY ON THE OCCUPATIONAL HEALTH HAZARDS
AT IRE, ALWAYE.

by
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To
Prof Banerji

with love and regard



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# INTRODUCTION

Trade union movement in India has not, so far, raised the issue of health and safety at the workplace, even though accidents and occupational diseases take a heavy toll in our fields, factories and mines. While the workers are generally aware of the hazards of the materials they handle day in and day out, ignorance of control devices force them to bear the agony. In the developed countries, where the issue came into sharp focus during the 70s, scientific community played an active role in educating the workers, their counterpart in India is yet to recognise the urgency of the situation.

As far as the employers are concerned, health and safety becomes an issue of concern under two sets of circumstances: (a) During a period of famine or war-imposed labour shortage, when labour becomes extremely scarce. (b) During a period of labour radicalisation, when the employers try to jump ahead of the working class movement by proposing a non-threatening health and safety package.[1] In the absence of the above two sets of circumstances, health and safety has remained a non-issue for business in India. In spite of a legislation comparable in scope to the developed world, our factories and mines maim and murder at will, not even a proper body count is done.[2] Research efforts are totally absent and there is a general lack of concern among policy makers, social scientists, medical professionals and trade unionists.

An Occupational Health (OH) study involves use of multidisciplinary techniques of medicine, environmental science, social science and law. To be complete, the study should focus on the health status of workers, quantify the pollution load in the work environment and study the health and safety apparatus available including the internal safety organisation and compensation structure, etc.

In this paper, an attempt is made to study the health status of workers of Rare Earths (RE) Division of the Indian Rare Earths Limited (IRE), Udyogamandal, Ernakulam, Kerala. IRE, an undertaking of the Department of Atomic Energy (DAE), is engaged in the processing of monazite sand found in abundance in Kerala and Tamil Nadu coasts. The plant under study has a processing capacity of 4000 tons of monazite a year. The main products of IRE are thorium rare earths (RE) chloride and zirconium. Thorium is at present used in the production of gas mantles. The metal, which derives its name from Thor–the Scandinavian war god–would be used as fuel in breeder reactor which is still in research stage. Zirconium is used for cladding of uranium fuel pellets for atomic reactors. The other important product–RE chloride–is used in Chinaware industry. India commands a share of one third of the world market for this product.

The Health Physics Division (HPD) of the Bhabha Atomic Research Centre (BARC) under DAE is entrusted with the sole responsibility of health and safety of workers in units under DAE. The Atomic Energy (AE) Act, 1962 prohibits an independent scholar or a research centre from making any inquiry into the affairs of DAE, including the health status of its workers.[3] Even though the DAE units employ more than 20 000 people, no data regarding worker's health status is available, except, of course, occasional briefings to the press made by the official spokespersons.[4]

## The Work Environment

As mentioned above, a typical OH study involves quantification of pollution load in the work place. This involves repeated measurement of radiation level/concentration of radionuclides with the help of sophisticated gadgets. Mainly because of the prohibitive provisions of AE Act, 1962, this could not be attempted.

In this section, the production process at the plant under study is described briefly and an attempt is made to identify some of the more hazarduous locations found on visits to the plant.

The main raw material used is monazite which is an orthosphate of 15 rare earth elements and thorium. The sand is ground in the ball mill to 400 mesh size after which a suction pump pulls out fine dust through a filter and deposits it in a bin. Dust is then mixed with dilute caustic soda (lye). The solution is then pumped into the attack tank where caustic soda (flakes) is added. The solution is then moved to a relay tank and leached with water. The first product of the process–Trisodium Phosphate (TSP), a general purpose detergent—is decanted here.

The remaining slurry containing hydroxides of rare earths, thorium, uranium, mesothorium and lead is pumped into a set of 'More Filters' where it undergoes filtration and washing. Traces of phosphate are removed and slurry is pumped into four extraction tanks where concentrated hydrochloric acid is added. At this stage, the RE fraction of the compound becomes RE chloride which is drained out and pumped into a deactivation tank in which barium chloride and sodium sulphate are added. Deactivation involves separation of radioactive elements like uranium, thorium and their daughters. These as well as lead are then allowed to precipitate in the tank. The precipitate is mechanically separated through press filters. The clear solution which is pure RE chloride, is decanted and the precipitate is scrapped off the press filters manually. Thorium hydroxide is also sent to another set of press filters to remove traces of RE chloride. Thorium hydroxide is scrapped manually and pumped into a silo.

While no spot in the IRE compound seems to be free of radioactivity, there are a few processes which involves considerable threats to the workers. Let us consider a few examples.

(a) *Ball Mill.* The mill where monazite is ground is not air tight. There are numerous holes through which dust can escape. Moreover, mill vents have to be opened frequently for sample collection. This is done manually by the operator/helper. Though respirators are given, the workers do not wear them because: (i) it is uncomfortable (ii) since a worker has to attend three spots, it is inconvenient and (iii) since the volume of air breathed is reduced considerably, the worker is not able to cope with the work-load.

(b) *Filter Press (Cancer Ward)*. At filters where thorium and mesothorium are pressed into cakes, materials handled are the richest in radioactivity. Here, work is done in pairs, each worker standing on either side of a 10x2 feet rectangular press, with a series of wooden frames. The top of the press is at chest level. The sticky concentrate has to be scraped from the frames using a metal sheet as big as a kitchen knife.

Workers on this job are given gum boots and rubber gloves. On the day of our visit, one of the two workers was not wearing gloves. He said that with gloves, the speed of work is reduced considerably. The Plant Superintendent who accompanied us did not ask him to use the "protection gear" either. Mesothorium has gamma activity. Rubber, anyway, is not a shield against this.

(c) *Lead sulphide disposal.* Lead sulphide (which contains lead, mesothorium etc.) collected in the R C C barrel remains unsealed for a week. The barrel is located by the side of a road leading to the canteen/dispensary. They are sealed once in a week. After a year or so the barrels are buried in the factory compound itself by a disposal team consisting of a crane operator from the Fertilisers and Chemicals Travancore Ltd. (FACT) and contract workers. The latter have to remain close to the barrel for placing its hooks.

According to the International Labour Organisation (ILO) guidelines, this class of radioactive waste can only be handled in "sealed-in operations, with people working in plastic suit with controlled ventillation"[5]. In IRE, workers wear only cotton khakhi uniform.

(d) *Thorium Silo.* Wet thorium hydroxide, kept in silos is removed occassionally for transportation to the Trombay facility. (This is a Government of India owned company which is under the management of IRE. Here, thorium hydroxide is converted into thorium nitrate for gas mantles and thorium oxide for research purposes). Since silos contain many hundred tons of thorium stored for over three decades, there is the possibility of a high concentration of thoron, a thorium daughter in gaseous form. According to ILO, air in silo has to be evacuated once every 17 minutes.[6] There is no facility for this in IRE. With radionuclides and thoron gas, work in silo can be equated to both a radiation bath as well as a radiation dust bath.

(e) *Open Vessels*. Almost all chemical treatment is carried out in open vessels. Spillover of considerable vintage has accumulated all over the vessels. Because of the openness, radionuclide and thoron gas float freely in the workplace. In almost all processes, external skin contamination is totally unavoidable because of the bad housekeeping.

The Plant Superintendent confided that vessels as well as the floor, which appeared no different from a paddy field during transplantation, had not been cleaned for over a decade.

While the above hazards are of a day to day nature, there are riskier operations which have to be performed periodically. Some examples are given below:

(a) *Digging the Pond*. After extraction of TSP, the remaining slurry is washed in three tanks. The slurry is moved from tank to tank with an electrically operated crane with a maximum capacity of five tons. At times, when the slurry is beyond the carrrying capacity ofthe crane, or due to some other faults, has to be removed manually. Workers, usually new recruits, enter the tank with a shovel. They can wear their gum boot, and rubber gloves, if they wish to. The slurry is removed with the shovel and this job is known as 'Kulam Vettal' which in Malayalam means digging the pond. The appropriate frequency of this event is once a month. The tank contains hydroxides of rare earths, thorium, mesothorium and uranium which have alpha, beta and gamma activity.

(b) *Digging the Grave*. Lead sulphide, the main solid waste, which contains mesothorium and other radioactive materials,is stored inside an RCC barrel which can accommodate 200 kg, the approximate output of a day. At times, when the output is more than normal, excess quantity bulges out of the polythene bag kept inside the barrel and is removed manually with a shovel. This has to be done approximately once every month. The materials have beta and gamma activity.

(c) *Occassional Activities*. Apart from these, occassional activities like shifting of godowns are done by contract workers. During 1983, dock workers of Cochin were employed to remove thorium concentrate stored in IRE godown near the port. According to an eyewitness, many of the MS drums in which the concentrate was stored were corroded and broken. During January/February 1985, casual workers were employed to shift

thorium produced during the early fifties to the present silo. No protection was given in the above cases.

Among the permanent employees, the exposure rate is not uniform for all categories of workers. While helpers remain in close proximity to the production process, operators and supervisors who do not have to do much of a manual handling, remain a little away from it. However, the management has made it a point to evenly distribute hazards among all the workers. This has been achieved in two ways: (i) In IRE, there is only one entry point for workers, they are recruited as helpers. The posts of operators and supervisors are time-scale-promotion based. (ii) After a complete monitoring of the plant by HPD in 1966, a permanent posting of workers to separate sections within the production line was discontinued. A rotation system was introduced under which every worker moves out of one section after a fixed interval.

The production technology was imported from France where it was developed in the forties and is out dated by nearly half a century. During those days, the awareness of radiation hazards was at a very low ebb, restricted as it was to a few radiologists. Between then and now, developments of a far-reaching nature have taken place. In IRE, however, the increased awareness of radiation hazards has not lead to any innovation to prevent it at source. Instead, cheap and totally inefficient measures like gloves and gum boots have been resorted to.

## Survey of Literature

Health effects of radiation can be classified into two: stochastic and non-stochastic. Stochastic effects are "those for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without threshold. Non-stochastic effects are those for which a threshold may therefore occur"[7]. According to the International Commission on Radiological Protection (ICRP) which recommends the standards for radiation, cancer and genetic disorders are stochastic effects.[8] Gofman, an authority on radiation and health, considers genetic effects as non-stochastic,[9] Other diseases caused by radiation are impairment of fertility, haematological deficiencies, cataract of lens, non-malignant damage to skin etc. There are

some medical researchers who strongly feel that radiation causes heart diseases also.

All what is needed to a trigger the process of carcinogenesis is damage to chromosome or gene of a single cell. There are trillions of cells in human body, each cell has 46 chromosomes and 25,000 to 100,000 genes. (Cells in gonads and ovaries have only 23 chromosomes). Any alteration of the deoxyribonucleic acid (DNA) which is the information base for the enormous biochemical capabilities of the cell, including instructions for carrying out the process of cell reproduction, can lead to loss of cellular control or cellular regulation. This loss of control results in proliferation of cells leading to the formation of a tumour[10]. If insult is directed against a cell in gonad or ovary, the effect is transmitted to the next generation.

Radiation can also result in cell death. If the quantum of cells destroyed is beyond the replenishing capacity of the organism, the net result could be one of non-stochastic effects mentioned above. For instance, a massive cell death in gonads leads to impairment of fertility.

Let us briefly review some of the researh findings in which a causative relationship between occupational/medical exposure to low level radiation and various health hazards has been established.

## Cancer and Genetic Disorders Among Offsprings

The first ever working class martyrs of radiation were the miners who worked in the uranium bearing ores in the Erz mountains of Central Europe during the 16th century. In 1879, Harting and Hese reported that half of the uranium miners in Germany and Czeckoslovakia died of lung cancer.[11] In a study of uranium miners of the US, Archer, etal, observed an incidence of 142 cancer cases, which is five times higher than the normal. The workers were observed from five years through 29 years after their initiation to mining.

In the 1920s, women radium dial painters in the watch industry of the US developed bone cancer, far in excess of the general population. These women used to put brushes to their lips to get a fine tip, thereby ingesting radium which accumulates in bones.[13] Evans observed 40 persons with a body burden

of radium ranging from 1 to 10 microcuries and discovered that there were 14 cases of bone cancer. The spontaneous occurrence of bone cancer in the US in 1960s was 60 per lakh.[14] Reviewing the literature, Gofman observed that "the studies of Evans and others have abundantly confirmed Mattland's original observation of bone cancer as radium dial painters' disease. Its story exemplifies, the gruesome consequnces of the philosophy of use first, learn later."[15]

Medical industry is one of the major users of radiation. It is only recently that the dangerous side effects of therapeutic/diagnostic radiaticn have come to light. In a follow up of 2215 children who were irradiated for tinea caps (a fungal infection of the scalp), Shore, et. al, observed eight brain tumours as aginst an expected frequency of 1.1. The average age of children at irradiation was 7.9 years, the dose of radiation penetrating to the brain was approximately 140 rads per child.[16]

It is generally conceded that ionising radiation is one of the most mutagenic agents known to human kind. In I6 years of experimentation with drosophila (fruit fly): teams of scientists all over the world using a variety of chemicals managed to produce about 200 viable mutations. Working alone, Herman J. Muller was able to produce 100 of these viable mutations in two months through irradiation with 50 KV X-ray. These are dramatic visible effects of exposure to radiation, but many minute changes in the genes are recessive and their effect is not immediately apparent in a population. With this understanding of the genetic load, ie, number of harmful genes carried in the permanent genetic load material of a generation, is undoubtedly much larger than would appear from the number of live-born offsprings with visible defects, and second that increasing the genetic load may not have immediate dramatic results.[17]

Schull, W.J., et. al, in their study of atomic bomb survivors, found that with 137 gonadal rems to both parents, the frequency of genetic disorders would be double the spontaneous rate. [18] Analysing all available studies on bomb survivors, Gofman places the doubling dose between 31 to 52 rems.[19]

Kochupillai, et. al, observed that the frequency of down syndrome at Chavara-Neendakara (in Quilon district, Kerala) which has a high background radiation (up to 2500 millirem/year) is considerably higher than the expected rate.[20] Evan and

co-workers, in their study of British nuclear dockyard workers, found that damage to chromosomes is three to four times greater than normal level at a dose of 2 to 3 rems/year.[21]

## Heart Diseases

The International Atomic Energy Agency (IAEA) and the ILO, in their joint meeting in 1960, observed that the incidence of heart diseases was pretty high among uranium miners. The meeting, however, did not elaborate this.[22] These organisations do not recognise heart disease as radiation-related.[23]

There is an increasing research evidence which shows that radiation also causes heart diseases. Earl P. Bendit suggests that the atheroselerotic plaque [24] is comparable to a benign tumour of the arterial walls "and if it is comparable, the search for initiating factors should be directed toward the genetic and environmental factors that cause mutation—the same kind of agents and conditions that transform cells and initiate cancers."[25]

Robert Stewart and Luis F. Fajardo followed up 411 patients suffering from Hodgkin's disease (a type of cancer) who were given radiation therapy. After a year of therapy, 5.8% patients developed heart disease. Further research on New Zealand white rabbits also yielded comparable results. The authors conclude that "this extremely steep dose-response relationship is strikingly similar to that observed in the human diseases." [26]

Arthur Elkeles advances a theoretical hypothesis for this. He considers calcium as the villain. After fulfilling its role in building up the skeletal system, calcium starts performing its destructive role. Known as transmineralisation, the metal settles down on soft tissues and takes part in the process of destruction. Since heavy metals like uranium, thorium and radium are metabolised in the same way as calcium, these also travel the same pathway. In his study of abdominal aortas, coronory and pulmonary arteries of humans between 20 to 80 years, Elkeles found that ash and alpha activity rose in abdominal aortas and coronary arteries with age. He concludes: "The concept is advanced that a progressive deposition of calcium, together with small but increasing amounts of alpha radiation, lead to

subtle injuries and to reactive changes in the connective tissues in the arterial wall, thus paving the way for development of atherosclerosis".[27]

Comments Rosalie Bertell: "There is a growing body of literature associating radiation exposure and heart disease. The decision to limit radiation health effect research and estimate to cancers, and even more restrictively to fatal cancers, appears to be more political than scientific"[28].

## Sterility

It is well known that radiation at higher levels can induce sterility. The biological process could be a massive cell death (in ovaries or testicles), beyond the replacement potential of the organism. We have a few laboratory evidences which show that thorium tends to concentrate in testicles. S K Tandon et.al. in their study of male albino rats observed: "The repeated administration of thorium nitrate to rats resulted in progressive increase in the concentration of metal in testis accompanied by increasing morphological damage with time, which indicate that the metal exerts direct toxic effect on the testicular tissue."[29]

Ovaries of women were irradiated to induce artificial menopause as part of fertility control research. The sterilising dose was found to be 700 rads. Apart from these women, there is no other human data on radiation and sterility.[30]

# The Number Game

In a letter addressed to the Prime Minister (PM), Prof. K. V. Thomas, member of the Lok Sabha from Ernakulam, alleged that 14 workers of IRE died of cancer between 1970 and 1984.[31] The PM, in his reply, promised that he would have the issue examined.[32] Earlier, in a memorandum addressed to the PM, all the recognised trade unions of IRE pointed out that the high incidence of cancer among workers can be attributed to radioactivity.[33]

In our review of literature, we saw that the cause-effect relationship between radiation and diseases like cancer, genetic disorders etc. has been well established. However, these diseases

can also be caused by agents other than radiation. There is no way to ascertain the initiating factor in carcinogenesis at present.

Since occupational diseases do not carry a lable indicating their origin, indirect methods have to be resorted to understand their aetology. Causative relationship between an agent and a disease is established through epidemeological studies, in which the incidence of disease in the exposed population is compared with that of a non-exposed population. An epidemeological study can be either retrospective or prospective. In the former, disease/deaths which have already occurred in the past is studied. In contrast, a prospective study is futuristic, the student waits for the event to occur. If a clearly identifiable trend is discernible, it is ethically sound to study the past, so that speedy remedial action can be initiated.

In this section, the incidence of cancer and mortality due to heart disease and all causes during 1970-1984 among IRE workers is being examined. In an epidemeological study, the two populations compared (the exposed and the control group) should belong to similar socio-economic, age-sex groups. Let us examine the available statistics on cancer among various populations and see if any of them can be used as the control group.

(a) *Kerala*: The Regional Cancer Centre(RCC), Trivandrum, reports 23,000 new cancer cases in Kerala every year. The RCC estimate is based on "population-based incidence rate of Greater Bombay projected to Kerala's population."[34] Projection of Bombay's rate to Kerala is likely to yield misleading results because of differences in: (a) sex-ratio between Bombay, and Kerala (716 females per 1000 males in Bombay, as against 1033 per 1000 in Kerala) and (b) occupational status, pollution load, stress, pace of life etc.

Because of the weakness of the estimate as well as variations in age-sex and socio-economic variables between IRE and Kerala as a whole, it is not possible to use Kerala as the control group for our study.

(b) *Employees' State Insurance Scheme (ESIS):* ESIS Udyogamandal which provides insurance umbrella for 8323 workers registered one case of cancer during 1984-85.[35] This low incidence can be attributed to the age structure of the insured workers—majority of them are below 35 years.

At the national level ESI Corporation (ESIC) publishes the morbidity profile of insured workers. As on 31 March, 1984, the Corporation had 6.12 million workers insured with it.[36] Though there have been serious criticisms of the poor services provided by ESIC, no objective case study of the working of the Corporation has been conducted so far. Hence, we are not in a position to evaluate the level of reliability of the ESIC data. There is another serious problem with the ESIC morbidity profile which is being discussed shortly.

Given the weakness of above estimates/data, use of a sample of industrial workers sharing a common socio-economic background would yield more reliable results. Adjacent to IRE, there are three more industries which form a cluster. These are the Hindustan Insecticides Limited (HIL), producing organochlorine pesticides like DDT and BHC, the Fertilisers and Chemicals Travancore Limited (FACT), manufacturing nitrogenous and phosphatic fertilisers and the Travancore Cochin Chemicals Limited (TCC) producing caustic soda, chlorine etc. HIL and FACT have carcinogens in their work-places, like BHC and DDT in the former and rock phosphate which contains uranium in the latter [37] Nine of the chemicals handled in TCC is known to be cancer causing. Moreover, since both IRE and TCC went into steam during the same year, the age composition of workers is more or less similar.

In TCC, caustic soda is produced by electrolysing sodium chloride (common salt) using mercury as cathode. Mercury is highly toxic, chronic exposure can cause neurological and skeletal disorders. Workers are also exposed to heavy concentration of chlorine which is a by-product. Over and above the pollutants released by their respective industries, the workers in both IRE and TCC have to live with invading pollutants from neighbouring factories—sulphur dioxide, ammonia and fertiliser dust from FACT and DDT from HIL.

In terms of wages and perks, both the population groups are on a more or less equal footing—the only difference being a higher rate of bonus and a liberal housing loan in IRE. On the health care front, workers receiving less than Rs. 1000 a month are insured under ESIC. Those earning above Rs. 1330 have a company medical scheme under which expenses incurred on treatment of workers and their families in private hospitals recognised by the management are re-imbursed.

TCC has a residential colony in Udyogamandal itself, which is a high pollution zone.[38] In contrast, workers of IRE have their residence scattered in the entire district. Hence, the pollution load in the living environment (beyond the factory) of TCC workers is higher than that of IRE.

In this study, we have used the workers of TCC as well as those insured under the ESIC as our control populations.

In the case of cancer, there is a time lag between the crucial exposure to carcinogen and the manifestation of the disease. Known as the latency period, this ranges from six to 30 years. In this study, we are examining cancer cases between 1970 and 1984. While the exact time of the crucial exposure cannot be known, we can be reasonably sure that the first worker diagnosed as a cancer patient in 1970 must have had his exposure at least six years before, i e, 1964. As such we would have to consider the worker strength of 1964 as the base line population.

In an industry, exposure to pollutants is not uniform among all categories of workers. For instance, the managerial staff has a lesser chance of exposure than the workers engaged in production, who have to remain close to the source of pollution. An estimated 20% of employees who are on non-production jobs (like clerks, peons) can be classified as the marginally exposed group. The remaining 80% of employees, whom we classify as the seriously exposed group are taken as the base-line exposed population.

These manipulations are not possible in the case of ESIC data because we have no way to ascertain the year of enrolment or the nature of job of the workers who have been diagnosed as cancer. As such, we would take the entire insured workers of the respective years as the base line population.

The details of exposed populations in IRE and TCC are given in Table 1.

Table I

Strength of Workforce in IRE and TCC–1964

| Industry | Total Strength | Marginally Exposed | Seriously Exposed | Remarks |
|---|---|---|---|---|
| IRE | 328 | 66 (20%) | 262 (80%) | |
| TCC | 550 | 110 (20%) | 440 (80%) | |

Source: Data in column 2 is based on *District Gazetteer*, Ernakulam, 1965 pp 391 (IRE) and 82 (TCC).

The Gazetteer shows 1960-61 strength of TCC which was 493.

Since ours is a retrospective study, we are examining the mortality profile of the past 15 years. Here, we are confronted with the problem of assessing the exact cause of death. What are the sources of information from which we can obtain reliable data? Firstly, the hospitals. While some hospitals informed us that the old documents are not preserved, two major hospitals refused to co-operate for reasons known to them only.[39] Then we looked into the register of births and deaths maintained by the local self governments. In many cases, the cause of death has not been recorded properly. This is an all-India phenomenon. It is only recently that the Indian Council of Medical Research (ICMR) has initiated a programme to maintain the mortality data in India according to the World Health Organisation (WHO) norms.[40]

Another source could be the personal dossiers of workers maintained by the management. Even this source is not free of errors as can be seen in the ensuing discussion.

Instead of depending on a single source, various sources as given below has been consulted so as to arrive at a near accurate conclusion.

Lists of workers who died along with the cause of death were obtained from the trade unions of IRE and TCC. The cause of death was cross-checked from dossiers. Cases in which the union data did not tally with the dossier, detailed interviews of co-workers, trade union activists, family members and neighbours were conducted.[41]

To enable comparison of the data of all the three population groups (IRE, TCC and ESIC), it has been converted into rate per 10,000. After conversion, the relative risk in IRE was estimated.[42] Statistical test (chi square) was used to see if the difference between the study and control populations is significant.

## Cancer

According to the unions 14 workers of IRE and four workers of TCC died of cancer between 1970 ond 1984. As per the IRE dossiers, only eight workers died of cancer. The findings on the six controversial cases are summarised below.

*(a) MJ Augustin.*

Dossier shows heart disease as the cause of death. According to family members and friends, he was suffering from heart disease and dermatitis. Augustine died of cardiac failure at St. Josephs Hospital, Udyogamandal. The unions have not been able to produce any substantial evidence for their claim that cancer was the cause of his death.

*(b) N K Thambi.*

Thambi, who died a short while after his retirement, was suffering from diseases of kidney, heart, brain and skin, and treated at the Christian Medical College Hospital (CMCH) Vellore. There is no mention of cancer in the medical papers issued by CMCH.[43]

*(c) K P Bhaskaran Pillai.*

Pillai was admitted to Taj Hospital, Sreemoolanagaram, Ernakulam District, with a severe head ache and died shortly after admission. Except for hearsay, the unions have no evidence to contest the disgnosis of the hospital which was subarchanoid haemorrhage (bleeding in the brain).

*(d) Thomas John.*

Unions claim that John died of stomach cancer, whereas the service dossier shows chronic pancreatitis as the cause of death. He was admitted to a small private hospital for pain in the abdomen during the first week of August, 1984. Seeing no improvement in his condition, he was shifted to Lissie Hospital, one of the well-equipped hospitals in Ernakulan district owned by the church. John's younger brother says: "After seeing the X-ray, Dr. Cheriyan (Surgical specialist) said that he was suffering from stomach cancer". John was operated on 23 August, 1984. On the third day, he developed fits and died instantly.

Two days before the surgery, Lissie Hospital took a barium meal X-ray, which is not the diagnostic method for confirming pancreatitis. If he were suffering from chronic pancreatitis, the surgeon might have arrived at the diagnosis on seeing the calcification of pancreas during the surgery. And the surgery could have been done to remove the suspected tumour. It is noteworthy that cases of chronic pancreatitis are usually referred to medical specialists. Surgery is indicated only in extreme cases.

John was a chronic alcoholic, diabetic and hypertensive. There is a strong association between these conditions and

chronic pancreatitis. He had been treated several times earlier for pain in the abdomen.

The unions allege that Lissie Hospital is a client of IRE and could have manipulated records. To verify this, the Hospital was approached with a request to provide the medical papers of Thomas John. We are told that old records are not preserved. Subsequently, Dr. E P Mohanan, a tutor in the Trichur Medical College approached one of his class-mates working with Lissie Hospital. Even he could not help.

(*e*) *Kunjuveeran*.

The personal dossier mentions costochondritis as the cause of death. Symptoms of this disease are swelling, pain and tenderness in upper joints between breast bone (sternum) and ribs. Costochondritis is self-limiting (cures even without medication) and *never fatal*. Hence, the dossier is wrong.

Months before his death, Kunjuveeran developed swelling of abdomen. After opening his abdomen, relatives of the patient were informed of the tumour which was big enough to be removed. He switched over to ayurveda and received treatment for *mahodaram* (ayurvedic equivalant for stomach cancer). This statement has been corroborated by ten respondents.

(f) *Thomas P K*

The cause of death has not been recorded in the service dossier. The symptom complex, as narrated by nine co-workers, relatives and neighbours of the deceased strongly suggests that he died of stomach cancer.

Out of the six cases mentioned above, it is impossible to accept the unions' claim of cancer as cause of death in the first three cases. In the case of Thomas John, it is difficult to arrive at a definite conclusion. The last two workers, we are reasonably sure, died of stomach cancer. This brings the total number of cancer deaths in IRE to ten. One worker is now under treatment for lung cancer. In all, there have 11 cancer cases in IRE since 1970.

Our data have the following serious limitations

(a) Workers who left service since 1964 have not been followed-up. Table II provides the service particulars of the existing work-force in IRE. Out of 471 employees, 67 started working before 1960 and another 30 joined between 1961-66. Average annual enrolment during 1961-66 being 5, there were

87 employees on April 1985, who belong to the pre-1964 stock. Thirtytwo workers of the pre-1964 stock are now in the managerial cadre, another 22 died while in service during 1970-1984, In other words, out of 328 base year worker population of IRE, 187 have either resigned or retired. Of these, 140 (80%) belong to the seriously exposed population. Since we do not know what happened to them, our result is likely to be a gross under- estimate of the exact risk in IRE.

## Table II

### Service Details of Employees of IRE – Managerial Staff Excluded

| Enrolled in | Service | Number |
|---|---|---|
| 1985 | Less than 6 months | 25 |
| 1982-84 | Upto 3 years | 89 |
| 1975-81 | 4 to 8 years | 164 |
| 1967-74 | 10-17 yrs. | 96 |
| 1960-66 | 18-24 yrs. | 30 |
| Pre-1960 | 24+ | 67 |
| Total | | 471 |

Source: Provided to trade unions by IRE management.

(b) The level of accuracy with which cause of death is recorded in the dossier is questionable. For instance, in one case, cause of death has been mentioned as "failure of heart" which is a layman's term for cardiac arrest. More revealing to the entry showing costochondritis as cause of death.

Details of cancer cases in IRE and TCC for the period 1970-1984 are given in tables III and IV. In Table V, incidence of cancer among workers insured with ESIC for period 1969-70 to 1983-84 is also provided. As Tables III and IV show, all cancer victims of IRE and TCC joined their respective employments before 1964 —the cut-off year for the study.

## Table III

### Cancer Cases In Indian Rare Earths–1970-1984

| Ser. No. | Name | Section | Age at Death/ Diagnasis | Date of death/ Diagnosis | Joined IRE in | Total Service | Site of cancer |
|---|---|---|---|---|---|---|---|
| 1. | M J Joseph | Water Works. | 46 | 7-3-71 | 1952 | 19 | Stomach |
| 2. | Philipose K | Packing | 45 | 22-4-72 | 1952 | 20 | Cheek 1 |
| 3. | P K Thomas | Plant | 44 | 26-9-76 | 1957 | 18 | Stomach 2 |
| 4. | Augustine K T | Plant | 45 | 26-9-76 | 1952 | 24 | Intrecranial |
| 5. | Kunjuveeran | Plant | 43 | 14-7-76 | 1952 | 24 | Stomach 3 |
| 6. | Pareed K | Plant | 56 | 30-1-78 | 1957 | 21 | Abdomen |
| 7. | John Kunhappi | Maintenance | 53 | 23-10-77 | 1952 | 25 | Liver |
| 8. | P B George | Plant | 56 | 1-5-78 | 1952 | 26 | Stomach |
| 9. | P C Vasu | Maintenance | 52 | 12-10-81 | 1952 | 29 | Leukemia |
| 10. | C Perrera | Plant | 52 | 21-3-82 | 1952 | 30 | Brain |
| 11. | K R Miehael (under treatment) | Dispensary | 55 | ec. 1984 | 1955 | 30 | Lung |

1 Site not mentioned in the service record.
2 Cause of death not entered in the service records.
3 Service records show costochronditis as cause of death. See text.

Source: Trade Unions of IRE, Service Records and Interviews.

## Table-IV

### Cancer Cases in TCC-1970-1984.

| Ser No. | Name | Section | Age at death. | year of death. | Service | Stte |
|---|---|---|---|---|---|---|
| 1. | V A Paul | H CL | 55 | 1978 | 24 | Stomach |
| 2. | V M Krishnan | H CL | 50 | 1981 | 23 | Stomach |
| 3. | John D Silva | H HL | 47 | 1982 | 22 | Stomaeh |
| 4. | Gopinathan | Cell | 48 | 1983 | 24 | Throat. |

Source: Trade Unions TCC.

In IRE, there were four cases of stomach cancer. The remaining cases are of different sites. While radiation injury can produce malignancy of any organ, there is a strong association between certain types of cancer and occupational exposure, like lung cancer among uranium miners and bone cancer among radium dial painters. Let us see if we can offer any explanatory hypothesis for the randomness of 'site of cancer' in IRE.

IRE has all kinds of radiation hazards, viz, external from beta and gamma rays, internal from ingested nuclides and inhaled radioactive gases like thoron and radon. The most serious threat in IRE seems to be from the internal emitters which are either ingested or inhaled. Now let us see the behaviour of internally deposited radioactive elements.

(a) Thoron is a noble gas (it does not react at all). It has alpha activity and a half life of 54.5 seconds. Polonium, the thoron daughter is a solid with alpha activity and a half life of 0.16 seconds. Next in the series is Thorium B with beta and alpha activities and a half life of 10.6 hours. While thoron does not react, her daughters get attached to the tissues nearby in this case lungs. And keep on damaging the cells.

(b) We have earlier observed that all heavy metals (including the radioactive ones) follow the course of calcium. In other words, as the ageing process sets in, ingested radioactive metals settle down at soft tissues all over the body.

(c) ITRC study quoted above reveals that thorium also settles down in testicles. Albert R.E reports that workers in plants refining thorium have shown chronic deposition of the metal in lungs, lever, kidneys, spleen and bones.[44]

All these evidences prove that once thorium enters the body, it behaves very randomly. So does tumour. Clumps of cancerous cells often break away from the parent tumour, migrates to new organs, seed out and start growing as secondary cancers, which are known as metastases (literally), "standing in an abnormal place"). Sometimes, the primary cancers remain undetected.

Because of these, we have taken all types of cancer (including leukemia) into a single group for the purpose of analysis.

## Heart Diseases

Let us now examine the incidence of heart diseases in IRE and TCC. The method of data collection for this has been the same as that of cancer.

Now, a word of caution. As mentioned earlier, workers of both the factories are exposed to invading pollutants from neighbouring factories. Among such pollutants, sulphur dioxide released by FACT is of more significance in terms of concentration as well as the associated health hazards. Chronic exposure to this gas leads to thickening of alvelio walls of lungs, causing respiratory diseases like bronchitis which, at a later stage, can graduate to heart diseases. This disease cycle is known as Chronic Obstructive Pulmonary Diseases (COPD). The incidence of respiratory and heart diseases is very high in the entire area.

Because of this, all the cases of heart diseases in IRE cannot be attributed to the pollution caused by the manufacturing process in the plant. Likewise, the frequency observed in TCC may not be the expected frequency in an average factory. Assuming that the pollution load by FACT is equal in both IRE and TCC, the difference in frequency between the two population groups can be attributed to the presence or absence of causative agents in their respective work environments.

The figures for IRE and TCC are fatal heart diseases. The ESIC data, which also is presented below represents the incidence only—not all of them might be fatal.

Details of heart diseases in ESIC, IRE and TCC are given in Tables V, VI and VII.

### Table V

### Incidence of Cancer and Heart Diseases Among Workers Insured with ESIC 1969-70 To 1983-84

| Year | Total insured Workers (lakhs) | Incidence per 1000 workers Cancer | Heart Diseases | Source for column 3 and 4 |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| 1969-70 | 36.65 | 0,7 | 0.8 | Indian Labour Year Book 1970, p 210 |
| 1970-71 | 39.39 | 0.5 | 0.9 | -do- 1972, p 130 |
| 1971-72 | 39.76 | 0.4 | 0.9 | -do- -do- |
| 1272-73 | 41.50 | 0.2 | 0.7 | -do- 1973, p 130 |
| 1973-74 | 42.05 | 0.3 | 0.7 | ESIP Annual Report 1981-82, p 64 |

| 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|
| 1974-75 | 43.85 | 0.4 | 1.2 | Indian Labour Year Book | 1975-75, p 156 |
| 1975-76 | 51.50 | 0.9 | 1.0 | -do- | 1977, p 153 |
| 1976-77 | 59.75 | 0.4 | 0.6 | -do- | -do- |
| 1977-78 | NK | 0.4 | 0.5 | -do- | 1978, pp 152-3 |
| 1978-79 | 59.40 | 0.3 | 0.6 | -do- | 1980-81 p 155 |
| 1979-80 | 59.83 | 0.3 | 0.5 | -do- | -do- |
| 1980-81 | 71.62 | 0.3 | 0.6 | -do- | 1982, p 133 |
| 1981-82 | 72.73 | 0.6 | 0.8 | ESIC Annual Report | 1981-82, p 94 |
| 1982-83 | 71.87 | 0.2 | 0.8 | ESIC Annual Report | 1983-84, p 94 (Mimeo) |
| 1983-84 | 69.68 | 0.3 | 0.6 | -do- | -do- |
| Total | | 6.2 | 11.2 | | |

Note: 1983-84 is the latest year for which morbidity date is available.

## Table VI

## Death Due to Heart Diseases-IRE 1970-1984.

| Ser No. | Name | Section | Age at Death | Date of Death | Joined IRE in | Total Service | Diagnosed by |
|---|---|---|---|---|---|---|---|
| 1. | Vasudevan Nair | Water Works | 48 | 6-5-70 | 1963 | 7 | St. Joseph's Manjummel |
| 2. | Raman Menon | Medical | 58 | 6-2-74 | 1953 | 21 | City Hospital, Ernakulam, |
| 3. | R Subbaiyan | Sanitary | 48 | 2-8-79 | 1963 | 16 | Govt. Hosp. Alwaye |
| 4. | V T John | Plant | 57 | 23-9-79 | 1955 | 24 | Not known |
| 5. | M J Augustine | Plant | 56 | 14-9-80 | 1952 | 28 | St. Josephs |
| 6. | T G Joseph | Maintenance | 60 | 1983 | 1952 | 30 | Not known |
| 7. | N K Thampi | Plant | 60 | 1982 | 1952 | 30 | C M C, Vellore |
| 8. | Prabhakaran | Ward | 55 | 1984 | 1956 | 28 | Gautham Hospital. |

## Table VII

### Death Due to Heart Diseases in TCC : 1970-1984.

| Ser No. | Name | Section | Age at Death | Year of Death | Enrolled in | Total Service |
|---|---|---|---|---|---|---|
| 1. | M L Chacko | Hydrosulphate | 40 | 1970 | 1955 | 15 |
| 2. | Sreedharan | Hydrochloric Acid | 45 | 1973 | 1958 | 15 |
| 3. | K N C Pillai | -do- | 38 | 1974 | 1961 | 13 |
| 4. | K Balakrishnan | Mercury Cell | 45 | 1979 | 1959 | 20 |
| 5. | A G Joseph | Hydrochloric Acid | 50 | 1979 | 1955 | 24 |
| 6. | Mendes | Workshop | 60 | 1981 | 1954 | 27 |

Source: Trade Unions of TCC

## Mortality Profile

So far, we have examined the frequency of two radiation-caused diseases–cancer and heart diseases. There is another group of diseases which is broadly classified as radiation–aided. We saw that radiation can also cause cell death. An absorbed bone marrow dose destroys white blood cells, which are essential for fighting infection. If cell death is massive, the organism would be rendered incapable of fighting even a very common infection.

Cell death can also lead to premature ageing. Measurement of the ageing process involves high technology gadgets which we have not been able to use. However, since the end result of ageing is death, consideration of the total mortality profile might reveal certain basic trends. Let us compare the total mortality (due to all causes other than suicide and accident) in IRE and TCC. (Mortality data pertaining to workers insured under ESIC is not available).

Details of workers of IRE and TCC who died of causes other than cancer, heart diseases and accidents are presented in Tables VIII and IX. Table X shows profile of mortality due to all causes (less accidents) of both the industries.

## Table VIII

### Death Due to Other Causes: IRE 1970-1984

| Ser No. | Name | Section | Age at Death | Year of Death | Joined IRE in | Total service | Diagonsed by | Diagnosis |
|---|---|---|---|---|---|---|---|---|
| 1. | Shankar | Water works | 52 | 1974 | 1952 | 22 | Not known | Jaundice |
| 2. | K P S Pillai | Work-Shop. | 47 | 26-6-75 | 1955 | 20 | Taj Hosp. Sreemoolanagaram | Sub-arch noid Haemorrage |
| 3. | Thomas John | Plant | 51 | 26-8-84 | 1952 | 32 | Lissie | Chronic Pancreatitis |

Source: Trade Unions IRE

## Table XI

### Death Due to Other Causes: TCC-1970-84

| Ser No. | Name | Section | Age at Death | Year of Death | Enrolled in | Total Service | Cause |
|---|---|---|---|---|---|---|---|
| 1. | V M Krishnan | Hydrochloric acid. | 50 | 1975 | 1955 | 20 | Cerebral Haemorrage |
| 2 | Pappachan | Mechanical Maintenance | 50 | 1983 | 1960 | 23 | Kidney failure |
| 3. | Devassy | Hydrosulpher | 40 | 1978 | 1960 | 18 | Liver Cirrhosis. |

Source: Trade Unions of TCC.

## Table X

### Death Due to All Causes-IRE and TCC: 1970-'84

| Ser No. | Cause | Number IRE | Number TCC | Average Age at death IRE | Average Age at death TCC |
|---|---|---|---|---|---|
| 1. | Cancer-All sites | 10 | 4 | 49.2 | 50.0 |
| 2. | Heart diseases | 8 | 6 | 52.3 | 46.3 |
| 3. | Others | 3 | 3 | 50.0 | 46.7 |
| | Total | 21 | 13 | 50.0 | 47.5 |

## Results:

In order to facilitate comparison between units, data presented earlier has been converted into rates per 10,000 in Table XI. In Table XII, relative risks between IRE/TCC and IRE/ESIC has been tabulated. Relative risk between IRE and TCC for cancer and heart diseases is 4.62 and 2.24 respectively. Coming to total mortality, IRE workers had 2.72 times a greater risk of dying of all causes. More pronounced is the relative risk between IRE and ESIC which is 6.77 and 2.72 for cancer and heart diseases respectively.

How significant are these differences? In the case of cancer, difference between IRE and TCC/ESIC is statistically significant at 0.01 level. For heart diseases, while the difference between IRE and TCC is significant at 0.2 level, the difference between IRE and ESIC is significant at 0.01 level. Difference in mortality due to all causes between IRE and TCC is significant at 0.01 level. In short, we can conveniently reject the null hypothesis.

### Table XI

### Incidence of Cancer and Heart Diseases and Rate of Mortality Per 10000 Population IRE, TCC and ESIC (All-India): 1970-1984

| Unit | Population | Cancer Nos. | Cancer Rate per 10,000 | Heart Diseases Nos | Heart Diseases Rate per 10,000 | Total Mortality Nos. | Total Mortality Rate per 10,000 |
|---|---|---|---|---|---|---|---|
| IRE | 262 | 11 | 420 | 8 | 305 | 21 | 802 |
| TCC | 440 | 4 | 91 | 6 | 136 | 13 | 295 |
| ESIC | 69.8 lakhs | 6.2 per 1000 | 62 | 11.12 per 1000 | 112 | NA | NA |

Note: ESIC data pertains to 1969-70 to 1983-84
Mortality data of ESIC not available.

### Table XII

### Relative Risks Between IRE-TCC and IRE-ESIC

| Ser No. | Disease | Incidence per 10000 IRE | TCC | ESIC | IRE/TCC | IRE/ESIC |
|---|---|---|---|---|---|---|
| 1. | Cancer | 420 | 91 | 62 | 4.62 | 6.77 |
| 2. | Heart disease | 305 | 136 | 112 | 2.24 | 2.72 |
| 3 | Total mortality | 802 | 295 | NA | 2.22 | NA |

# Genetic Disorders and Infertility

During the course of the study, we also stumbled upon a few cases of sterility among workers and genetic disorders among their offsprings. The data we are going to present here is not comprehensive. Major reasons for limitation in data are as follows:-

(a) Most diseases of autosomal dominant variety manifest themselves at a later age. The parents do not perceive such cases as genetic.

(b) A welfare measure in IRE has made any survey (with limited resources) of families virtually impossible. IRE is one of the few industries in India which has a unique housing scheme. An employee can build a house with a liberal loan from the company at a place of his choice. Since every worker with a minimum of ten years of service can own a house under this scheme, the unions did not press for a housing colony. Few workers in IRE feel that the liberal scheme was introduced for concealing the increased incidence of genetic disorders among the employees' offsprings. Incidentally, the scheme was introduced a couple of years after the health physicist team took position in IRE.

The details of genetic disorders are presented in Table XIII. Out of 17 cases, provisional diagnosis of four children belonging to one family is given below.

*Clinical History of GD3* [45].

Joined the Thorium Plant at Trombay as a Helper in 1956. He was married to his maternal cousin in 1955 at the age of 24. She conceived their first child in 1957, when GD3 had completed one year of service at the Trombay Plant. In 1958, he was transferred to IRE, Alwaye. At Alwaye, as a fitter in the Maintenance Section, he has to, at times, enter the reaction chambers for cleaning the rubber lining. Provisional diagnoses of all his children are given below:-

(*a*) *First Child Male (27*).

Showed difficulty in walking since early childhood. His condition deteriorated progressively. Appears to be retarded, both physically and mentally and is short-sighted also. Physiotherapy using ayurvedic oils has slightly improved the condition of his lower limbs. With strain, he can now walk short distances.

## Table XIII

### Congenital Anomalies/Genetic Disorders Among Offspring of IRE Workers

| Code No. | Section | No. of Children affected | Diagnosis | Remarks |
|---|---|---|---|---|
| GD 1 | Elect. | 1 | Mental retardation | |
| GD 2 | Plant | 1 | Not known | |
| GD 3 | Maintenance | 4 | See text | |
| GD 4 | Office | 1 | Muscular distropy | |
| GD 5 | Canteen | 2 | Not known | |
| GD 6 | Transport | 1 | Not known | |
| GD 7 | Plant | 1 | Congenital heart disease | Died |
| GD 8 | Plant | 1 | Not known | Died |
| GD 9 | Plant | 1 | Lung disease | Died |
| GD 10 | Plant | 2 | Hydrocephaly | Died |
| GD 11 | Maintenance | 1 | Swelling elbow | |
| GD 12 | Plant | 1 | Blackish lesion over face | |

Sources: 1. Trade unions of IRE
2. Workers in response to a questionaire

Note: Names withheld on request.

*Second Child Female (23).*

The girl had no problem till the age of 16. An average student, her eye-sight started weakening (short sight) at the age of 16 and was forced to discontinue her studies. Though she appears to be physically normal, there is a slight abnormality in her gait. In both the cases above, the diagnosing physician suggests the possibility of neural lesion, causing myopia.

(c) *Third and Fourth Children, Female (17), and Male (14).*

With very weak lower limbs, they spend most of their lives squatting on the floor. Appear to be suffering from severe mental retardation. In a strange gait, they can walk short distances with great difficulty. For this, they make a semi-circle with one leg, in the process touching the other toe and knee. The activity is repeated with the other leg. The diagnosing physician suggests cerebral involvement with a lesion in the basal ganglia.

Among the effected workers, GD3 alone presented the children before a medical board, consisting of three doctors of Lissie Hospital, Ernakulam. The board ruled that the cases be attributed to inbreeding.

There are two types of inheritance of genetic disorders-autosomal dominant and autosomal recessive. In autosomal dominant inheritance, only one of the parents supply a defective gene, while in the recessive inheritance, both the parents supply the defective gene at the same genetic locus. The 'book' has the following to say on the nature of interitance:

> In as much as recessive diseases require the inheritance of a mutation at the same genetic locus from each parent, when the genes are rare, the likelihood of any two parents being the carriers for the same defect becomes small. However, if the parents have a common ancestor, and if that ancestor was a carrier of the recessive gene, then the likelihood that two of the descendants have inherited the gene becomes relatively great.[46]

A person who has inherited a defective gene which lies dormant would not be affected by the disease. He or she is called a carrier. When two carriers of the defective gene at the same locus mate, the statistical probability of inheritance is:

> twenty five percent of the children will be normals, 50% would be heterozygous carriers and 25% would be homozygous and effected with the

> disease...........Since with recessive inheritance, only one of the four children in a sibship is expected to be affected, multiple cases in a family might not occur.[47]

In the case of GD3, all the four children have been affected. Moreover, according to the worker, he and his wife are sixth in a chain of consanquinity. This introduces an increased possibilit- of some other relatives also being affected. No one has been, so far. Secondly, as the provisional diagnosis shows, all the children do not share the same symptom complex or clinical history. This suggests the possibility of damages at different genetic loci. Hence the probability of both the husband and wife carrying several damaged genes seems to be extremely remote.

## Infertility:

Details of workers suffering from sterility are given in Table XIV.

It is not possible to assess at this stage as to whether all these cases are radiation-related. If they are, then the situation in IRE would have historical significance. IRE, in that case would be the first reported nuclear facility in the world to cause radiation-induced sterility among workers.

Cases of sterility need a closer examination. In the survey of literature, we saw that unlike cancer and genetic disorders, sterility is a non-stochastic effect which has a safe threshold. Since there is no history of radiation-induced sterility among males, the exact sterilising dose is not known. Sterilising dose for females is 700 rems, administered during a short span of time. Since ovaries are more protected than testicles, male sterilising dose should be lesser than that of females. One estimate places the dose at 600 rems. Assuming that the workers became sterile during the first 12 years of their service, the annual average exposure works out to 50 rems-which, incidentally, is ten times higher than the maximum permissible limit.

## Table XIV
## Infertility Among Workers–IRE

| Sl. No. | Code No. | Section | Age | Service | Remarks |
|---|---|---|---|---|---|
| 1. | S1 | Estate | — | 32 | Retired and died |
| 2. | S2 | Workshop | 60+ | 33 | Retired |
| 3. | S3 | Plant | 60+ | 30 | Retired |
| 4. | S4 | Plant | 52 | 24 | In service |
| 5. | S5 | Plant | 48 | 23 | In service |
| 6. | S6 | Plant | 55 | 21 | In service |
| 7. | S7 | Office | 40 | 18 | In service |
| 8. | S8 | Office | 60+ | 30 | Retired |
| 9. | S9 | Waterworks | 40 | 10 | In service |
| 10. | S10 | Plant | 36 | 11 | In service |

Source: Trade Unions of IRE
Note: Names withheld on request.

## Health and Safety Apparatus

The HPD of the BARC is responsible for monitoring the health of workers in all DAE undertakings. Health physicists were posted in IRE, Alwaye, in 1962, ten years after the factory went into steam. In 1966, the team recommended a few safety steps, like rotating workers from spot to spot after a fixed interval, provision of gum boots and rubber gloves etc. HPD is supposed to monitor the dose absorbed by workers and take remedial action in critical cases. Monitoring is done by analysing the film badges worn by workers. Film badge analysis alone is not adequate in an industry like IRE where the major hazard comes from radionuclides and radioactive gases like radon and thoron. A near accurate account of the dose absorbed can only be made through analysis of biological samples which is not being done in IRE. Even the results of film badge analysis is not communicated to the workers. similarly, HPD had conducted a chromosome analysis of Alwaye workers during the late seventies, the result of which has also not been communicated so far.

In the past, three workers were transferred to less hazardous jobs because of adverse medical findings. In these cases, the workers who had got medical advice from private practitioners had to fight their way out for transfer. HPD, rather than assisting in such cases, strongly opposed the transfers.

Even though all workers suffering from occupational diseases are entitled for compensation under the Workmen's Compensation Act, 1923, no one in IRE has got it so far.

In short, there is nothing much to comment on the health and safety apparatus in IRE.

## Conclusion

Chromosome aberration, chemical change of DNA and cell death are the immediate cellular responses to an absorbed dose of radiation. The end result could be any of the stochastic or non-stochastic diseases mentioned earlier. In this paper, we have been able to demonstrate statistically significant differences in incidence of cancer and mortality due to heart diseases and all causes between IRE workers and control populations. The incidence of sterility amony workers and genetic disorders among their offspring reported above is seemingly higher than their spontaneous occurrence in general population.

A retrospective epidemological study of this nature, can only formulate clinical hypothesis. At best, one can state that the study population was exposed to the agent under consideration during the reference period—in this case, till 1964. Incidentally, two years after this, the socalled control measures were introduced in IRE by HPD. How effective are these measures? To obtain an answer through an epidemological study, one would have to wait a few more years. Fortunately, we have a little more concrete evidence. In 1978, BARC conducted a chromosome study of IRE, Alwaye, workers. Though the results of this study are yet to be published, there is a reference to this in one of the DAE annual reports:

"In continuation of the efforts to evaluate the biological effects of high background radiation on human population residing in the monazite belt (Chavara Neendakara in Quilon district, Kerala), chromosome analysis was carried out on 179 samples.

"Under our chromosome analysis programme, broad samples in the normal background radiation areas and high background areas were analysed. Data on nowborn and their mothers did not indicate any differences in the chromosome aberration frequency between samples from normal background radiation areas and those from high background radiation areas.

"In the samples taken from the IRE workers at Alwaye, a high aberration frequency was indicated than that observed in the high background radiation, Chavara and Manavalankurichi samples.[49]"

In short, workers health was, and is still in jeopardy.

During the course of our study, we also found that there are gross irregularities in the fields of radioactive waste managements, as well as storage and transportation of radioactive materials—issues which are beyond the scope of this paper and hence being reported separately.

The situation is alarming. This calls for immediate action. The management of IRE has agreed for palliative measures like scanning of all workers for tumour by the Cancer Detection Centre, Cochin. Which is not enough in a hot spot like IRE.

The need of the hour is a comprehensive, inter-disciplinary study of the plant and the workers. In order to take effective remedial action, there should be a health survey of the workers which should include analysis of urine, blood, chromosome and tissues of critical organs like gonads. The workers who have absorbed dose above the permissible levels should be removed to safety. In the case of work environment, activity status of each spot would have to be measured and engineering measures adopted.

Such a study should have representation from the workers as well as the people, because what at stake is not only the health of over 500 employees, but also the national gene pool which the present decision-makers have no right to tamper with. We do not own the gene pool.

A clearer understanding of the exact magnitude of hazards posed by IRE assumes national importance at this juncture of our history. Because, IRE is the only DAE centre which has completed 30 years of operation which, incidentally, is the average latency for cancer. Today, DAE

is pushing forward its ambitious plan which involves tenfold expansion of nuclear electricity generation by 2000 A D. Before allocating a massive Rs. 22,177 crore from the public exchequer for the planned expansion, the people have a legitimate right to look into the track record of the DAE during the past three decades of its existence.

## Acknowledgement

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23. ILO Encyclopaedia (*op cit*) which is a near comprehensive document on occupational diseases has no mention of radiation-induced heart diseases.
24. Atherosclerotic plaque is a lumpy thickening of the arterial wall which narrows the passageway and initiates formation of a blood clot that can ultimately close down a critical artery.
25. Earl, P. Benditt (1977), "The Origin of atherosclerosis", *Scientific American*, Feb. 3, 1977. Benditt proposes that there are three stages in the patheogenesis of atherosclerosis, the first one being the "initiation stage during which there is mutation in an arterial wall cell". And then "among the possible initiating factors are intrinsic genetic ones that lead to excessive mutations and such extrinsic ones as chemical mutagens, viruses and possibly ionising radiation...... The idea that atherosclerotic plaques may be some form of neoplasm or abnormally proliferating tissue, is quite startling if one's concept of a neoplasm is limited to malignant cancer which spreads. Many tumors, however, are benign. As a matter of fact, a current concept of how cancers originate postulates that several successive mutational steps are required before extreme loss of control allows the tumor to spread."
26. J. Robert Stewart and Luis F. Fajardo (1971), "Radiation-induced Heart Diseases: Clinical and Experimental Aspects" *Radiologic Clinic of North America*, XI, No 3, pp. 511-531.

27. Arthur, Elkeles(1966), "Atherosclerosis and Radioactivity", *Journdl of American Geriatic Society*, XIV, No.9, pp 895-901. See also "Metabolic behaviour of Alpha Ray Activity in Large Human Arteries : Relationship to Atherosclerosis" by the same author in *Journal of Americal Geriatic Socicty*, XXVI, 1977, pp 179-82. In the similar line, Martel points out that the higher line incidence of cancer and heart diseases among smokers is due to the radioactivity in cigarettes. "It seems reasonable to conclude that the polonium-210 alpha irradiation of cells is the likely cause of cancer and a contributing factor in the early development of atherscle-rosis in cigarette smokers. On this basis, the epidemolo-gical health effects of cigarette smoking provides a valuable guide to the possible consequences of chronic exposure to the inhalation of insoluble particles of moderate to low alpha activity. For tbis reason, the unfortunate health experiences of cigarette smoking may prove to have been a blessing to mankind in forewarning us all, of the possible conseque-nces of a nuclear energy economy." Martel, E. A. (1975), Tobacco Radioactivity and Cancer in Smokers", *American Scientist*, 63, pp 504-512.

28. Bertell, Rosalie, *op cit*. p 22

29. Tandon, S. R., *et al* (1975), "Thorium-induced Testicular Changes in Rats", *Acta biol. med. germ*. Band 34, pp 1835-1842.

30. Brinkely, D., and Haybittle, J. L. (1969), "The late effects of artificial menopaue by X-radiation", *British Journal of radiology*, 42, pp 519-521.

31. Letter to Prime Minister, No. Nill, dated 19 April, 1985.

32. Prime Minister's letter dated 23 April, 1985.

33. Memorandum to PM, undated.

34. Personal communication dt. 18 Dec. 1934 from P. Ganga-dharan, Biostatistician, RCC, Trivandrum.

35. Copied from ESI Local Office, Udyogamandal, registers.

36. Corbett, Thomas (1977) *Cancer and Chcmicals*, Nelson-Hall, Chicago, pp 82-83.

37. ILO (1983), *op cit*. II, p 1679.

38. Concentration of sulphur dioxide and particulates in the area measured by the National Environmental EnSineering Research Institute (NEERI) is given below:-

| Month/year | Total Samples | Sulphur dioxide | | Suspended Particulate matter | | |
|---|---|---|---|---|---|---|
| | | 4 hrs max | Days Max | AM | Max | AM |
| Jan 1980 | 3 | 423 | 150 | 76 | 186 | 173 |
| Fed 1980 | 2 | 60 | 38 | 24 | 161 | 145 |
| Mar 1980 | 3 | 177 | 63 | 39 | 115 | 101 |

Unit: Microgramm/cube meter

Sampling frequency: Every 10th day–24 hrs.

AM–Arithmetic Mean

4 hrs. max–Maximum recorded in 4-Hourly day's sampling in the month.

Days max – Maximum calculated for 24 hours in month.

Note: There was only one sampling station located half a kilometre north of FACT.

Source: NEERI data received from the World Health Organisation (WHO), vide letter No. ICP 003 dated 05 October 1984.

39. Lissy Hospital and Medical Trust Hospital, Cochin are the major hospitals which refused to co-operate without assigning any reason.
40. Gangadharan P. *op cit*
41. Dr. E. P. Mohanan of Trichur Medical College was present in many of these interviews. Statements involving medical judgments are his.
42. "Relative risk is the ratio between the incidence among exposed and incidence among non-exposed". See, J. E. Park and K. Park (1981), *Text-book of Preventive and Social Medicine*, Jabalpur. pp 279-280.
43. CMCH, Vellore out-patient medical report No. 3/1-132105/A/81 dated 1-7-81
44. Albert, R. E. (1966), *Thorium: Its industrial Hygiene Aspects*, Academic Press, New York/London, p p 58-64, quoted in Tandon, S. K., *et. al.* (1977), "Effects of Monazite on Body Organs of Rats", *Environmental Research*, 13, pp 347-357
45. The provisional diagnosis was done by Dr E. P. Mohanan and a group of students of Medical College, Calicut.
46. Robert G. Petersdorf, *et. al.*, (ed) (1983), *Harrison's Principles of Internal Medicine*, 10th edition, McGraw-Hill, p 319
47. *Ibid*, p 318
48. Government of India, Department of Atomic Energy (DAE) Annual Report 1978-79. p 38.